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Silliman - Introductory Lecture - 1828.



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1918

AN

INTRODUCTORY LECTURE,

DELIVERED

IN THE

LABORATORY OF YALE COLLEGE,

OCTOBER, 1828.

BY PROFESSOR SILLIMAN.

NEW HAVEN:

PRINTED BY HEZEKIAH HOWE.

1828.

INTRODUCTORY LECTURE.

HUMAN KNOWLEDGE—SOME OF ITS OUTLINES—SENSIBLE OBJECTS—THE PHYSICAL SCIENCES—CHEMISTRY.

Among the privileges which the Deity has conferred on man, one of the greatest is the capacity and the disposition to acquire knowledge. Our species is thus distinguished from the various orders of inferior animals. Although they possess, in common with us, corporeal powers and appetites; although they are endowed with perceptions and impulses, (called instinct,) guiding them, with unerring certainty, to the accomplishment of the various purposes of their existence; although their progress towards the perfection of their faculties, is, in general, rapid, and a few days or weeks, may impart to them the power to provide for, and to protect themselves, while, with man, many years must elapse, before this ability can be attained; still, the Creator has established limits both to their knowledge, and to the development of their faculties; and the earliest individual of the race, is, in knowledge and power, precisely on a level with the most recent.

But, to the advancement of the human mind, there are no limits:

“The world is all before us, where to choose,
————— and Providence our guide.”

Unlike the inferior animals, man is scarcely guided by instinct at all, and the impulse of that power is perceived principally, in infancy, when reason is the weakest. Reason is gradually developed, as we advance to maturity, and then

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DISTRICT OF CONNECTICUT, ss.

***** BE IT REMEMBERED, That on the sixth day of November, in
* L. S. * the fifty-third year of the Independence of the United States of
* America, HEZEKIAH HOWE, of the said District, hath deposited
***** in this office, the title of a Book, the right whereof he claims as
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"An Introductory Lecture, delivered in the Laboratory of Yale College,
October, 1828. By Professor Silliman."

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CHARLES A. INGERSOLL,

Clerk of the District of Connecticut.

A true copy of Record, examined and sealed by me,

CHARLES A. INGERSOLL,

Clerk of the District of Connecticut.

THE substance of the following pages has been, more than once, communicated to my pupils, at the beginning of my annual courses of lectures. Some of the students having requested leave to take copies, which it was not then convenient to permit, I have now revised and printed the remarks.

They are not intended for adepts, but for young men, and especially for my own pupils, to whom, should they serve to convey a just idea of the connexion of some of the most important topics of knowledge, and of their bearing on the discipline and illumination of the youthful mind, in a course of liberal education, my wishes will be answered.

becomes a complete substitute for instinct ; while, in the inferior animals, this latter faculty becomes more perfect as they advance, and appears to be, at all times, their chief guide. Man, although below the humblest intelligence of the spiritual world, is elevated far above that of the animal creation ; still he frequently degrades his nature, by surrendering himself to the dominion of appetite and passion. If, in his most improved state, he is scarcely inferior to the angels, in his most ignorant and corrupt condition, he is but little elevated above the animal and sensitive world. In those countries, (unhappily too numerous,) where, through a sort of necessity, this is his condition, he is more an object of pity than of scorn. But, in more favored regions, where the blessings of literature, of science, of arts, of liberty, of order and of christianity, conspire to elevate the standard of taste, of thought, and of morals ; where so many things unite to make man wiser and better, and so few contribute necessarily to make him worse, we should naturally expect that correspondent advances would be made, in knowledge, virtue and happiness.

In such a country, where learning opens so many inviting prospects, it becomes interesting to survey, both the extent of human knowledge, and the most prominent boundaries of its great divisions.

I. MORAL SCIENCE.—Beyond all comparison, the most important branch of knowledge, is that which informs us of our condition, as moral and accountable beings, and of our relation to the Creator, and to each other. Religion, the parent of moral science, is derived, in part, from nature justly viewed ; but, its principal, and only infallible source, is the direct revelation which it has pleased the Almighty to make, through the gospel of reconciliation. It is neither superfluous, nor impertinent, to mention it on the present occasion. It is at the head of all sciences ; it is the only revealed one, and it is necessary, to give a proper use and direction to all

the others. There is no man, who is not interested in its commands, in its terrors, and in its consolations. Nay, is it not necessary, even to justify our present pursuits, by informing us that every creature of God is good, and to be received with thanksgiving; that the works of the Lord are sought out by all them that have pleasure therein; that in the beginning, God created the heavens and the earth; that in the end, the heavens shall be rolled together as a scroll; that they shall pass away with a great noise; that the elements shall melt with fervent heat, and that the earth, and all things that are therein shall be burnt up.*

These few allusions alone, contain our justification for studying the works of the Creator, which are pronounced to be *very good*; and they repress our pride and exclude every approach of atheism, by informing us whence the creation arose, and what will be its final catastrophe.

II. LANGUAGE.—One of the most important attainments, which distinguishes man from the inferior animals, is language. Without language, our communication of ideas would be limited to a few simple subjects, relating, principally, to our physical necessities, enjoyments and dangers; and our expressions, with the exception of a few inarticulate aspirations, (probably not superior to those which mere animals employ,) would be confined to the use of signs.

We see, with what vast labor, (demanding too, the persevering efforts of several years,) some good degree of knowledge, on a few of the most important subjects, is imparted to the deaf and dumb. When we consider too, that this art had its origin, and acquired its perfection, from men endowed with the faculty of speech, communicating in this manner, freely, with their fellow men, and thus drawing to their aid, the resources and the ingenuity of many minds; we may

* As to the bearing of these expressions on our interests, it is of little moment, whether they are understood in a physical or moral sense.

well imagine, what would have been its imperfections, or rather, what would have been its utter insufficiency, had it originated with, and depended solely upon the deaf and dumb. Language, therefore, as it is one of the earliest, so it is one of the most important gifts of God to man, and one, without which, his other bounties would have been comparatively useless. By means of this great agent, social intercourse is maintained, the most delicate emotions are expressed, the nicest shades of thought are delineated, and instruction on every subject is adequately conveyed. With the aid of letters, (and especially since the invention of that stupendous engine, the press,) every country may participate in the ideas of every other; valuable exports and imports are made, not merely of commodities, but of thoughts; and discoveries, and records of facts, and descriptions of external objects, are transmitted, as a rich legacy, to future generations.

The Bible itself, incomparably more important to man, than all other books, is dependant upon language and letters. Thus also, we ascend to the earliest periods of human learning; and the wisdom of ancient Persia and India—of Arabia and of Egypt—of Greece and of Rome is laid at our feet.

The study of language, is therefore, justly considered, as an important part of learning, and, as such, it will always be regarded, by every correctly informed mind.

It is thus appreciated, not merely because it is the vehicle of every species of information, for the study has many inherent advantages. It greatly invigorates the memory; it supplies a copious store of both words and thoughts; it gives much precision and delicacy in the choice, employment and definition of words; it facilitates etymological research, and thus indissolubly binds the word and the thought together. Its analysis is a refined species of logic; and even the labor of translating and parsing is highly conducive to habits of accurate discrimination, and to the formation of a sound

judgment. The study of language affords us also, the very best means of estimating correctly the intelligence, the learning and moral refinement, the political and religious condition, and indeed, we may add, the very employments and history of the people to whom it belonged. Probably, no language, not even that of a barbarous nation, could be learned, without improvement. How much then, must be derived, from the study, of the refined and copious languages of Greece and Rome; in which, for so many ages, was contained nearly all the valuable knowledge of man; and how much from the oriental tongues, and especially from the Hebrew, which, in common with the Greek, was rendered sacred, by being employed, as the vehicle of inspired communications to man.

III. RHETORIC AND ELOCUTION.—If the study of language is an interesting and rational employment, a similar character will be discovered in its cognate pursuit, rhetoric and belles lettres. Founded on universal grammar, and the most enlarged analysis of language, it makes appropriate and abundant returns, by supplying the most exact, luminous, beautiful and forcible expressions. Like language and grammar, it is so intimately connected with a subtle logic, involving numerous and delicate discriminations, that it cannot be separated from a system of just and accurate thought. Rhetoric is not therefore, as some imagine, chiefly a collection of tropes and figures; the mere iris and halo of a splendid imagination; it is the accurate, elegant and energetic exhibition, of the thoughts of the mind; and if it claims also for its domain, the grace and the sublimity, as well as the precision and the strength of language, this is a combination of qualities, not more extraordinary than that found in the royal gem which is, at once, the firmest, the hardest, and the most imperishable of natural bodies, while it is also when polished by art, the most resplendent and beautiful of all things. Rhetoric includes

not only the power of writing with propriety, strength and elegance, but it also demands that he who communicates his thoughts, by the living voice, should perform this duty in an impressive and interesting manner. Distinct articulation; appropriate emphasis; a varied, and flexible intonation; intelligent and sympathetic expression of the features; a graceful and dignified position of the body, and scope and appositeness of gesture, are among the leading attributes of a good speaker: if also they are united with a voice of an agreeable and forcible tone, and with a good countenance, and person; and more than all, with the earnestness of sincerity, and the ardor which is kindled by a good cause, and an honest aim, the speaker can scarcely fail to command his audience.

IV. LOGIC.—It would be in vain, that men learned to write, and to speak, with propriety, if they did not also learn to think and to reason correctly. This constitutes the province of Logic, so far as it is distinct from sound rhetoric; for, as has been already remarked, these two subjects hold a most intimate connexion; nor is it either necessary, or possible, to effect a complete separation. All men, possessed of sound intellectual faculties, reason, more or less extensively, and correctly, whether they have studied Logic or not, and some, who have not attended at all to this science, reason with great clearness and energy. Still, it cannot be doubted, that in all common cases, it is highly advantageous, to study the art of reasoning, as it is gradually developed in a regular system, and that thus an intellect, of a given degree of strength, will be enabled, sooner, and more effectually, to put forth its powers, and to arrive at the final object of all reasoning, which is the discovery and exhibition of truth.

Men may indeed fight, without having learned tactics, and if their warfare should always be maintained, with those like themselves, they would stand on equal ground; but if drawn into the open field, to contend with veterans, who add skill

and experience to courage and strength, they will find it a hard, and it may be, a disastrous conflict. Indeed, who that perceives the beauty and utility of a good definition, including all that is peculiar, and excluding all that is extraneous, to the subject in hand ; who, that values the safe and agreeable march of the understanding, through a course of induction, where every step is securely founded on a preceding one, and the last enables the intellectual observer, to survey, as from an eminence, the solidity and dimensions of all that is below ; who, that takes this view, can fail to consider the science of Logic as being, in every species of investigation, an important auxiliary to the human understanding.

If the science of logic commands our respect and regard, we can scarcely treat with indifference, its highest application, that is to

V. METAPHYSICS.—The science which treats of the general affections of being ; of the first principles of our knowledge and of our universal ideas, must be worthy of our attention. It is true, our notions of these affections and principles, are often very imperfect, and vague ; we are indeed certain that they must always involve, to some extent, both imperfection and error ; but, this misfortune attaches itself, in some degree to every branch of human knowledge, and is therefore not the *peculiar* reproach of any. Metaphysics, on account of the exalted and recondite nature of the subject, has probably suffered more than any branch of knowledge, from unskilful treatment and injudicious application. It should not be too often brought into view, nor ever be unnecessarily obtruded ; but there can be no doubt that “ every science has its own metaphysics ” and to the eye of God, who perfectly and intuitively comprehends the whole, there is no where either obscurity or inconsistency, but all is harmonious and excellent, in every department of knowledge, and in every province of the immense creation, of mind and matter.

VI. GEOGRAPHY.—That branch of knowledge, by which we learn the nature of the surface of our own planet, its varieties of aspect, its great natural divisions, its climates and productions, and, (in a more extended and less physical sense,) the character of its various families, their institutions, manners, resources and employments, constitutes the department of geography. Although less abstruse than many branches of knowledge, it yields to few in importance, or in interest. It draws its resources principally from the researches of travellers and navigators, and appropriates the treasures of information, amassed in their adventurous wanderings. It is indispensable to the correct comprehension of history, to the enterprizes of commerce, and of war, and to the most interesting of those of benevolence and humanity. A knowledge of this subject is inseparably connected with natural history, as conveying accurate designations, of the regions, in which are found the various productions of the three great natural kingdoms. Who, for instance if correctly informed in Geography, would look for the Camel or the Elephant on the Uralian Mountains, or for the white Bear or the Rein-deer on the deserts of Zahara. Who would expect to find the sugar cane, the palm or the bread fruit tree in Greenland or Zembla, or the larch or fir on the plains of Cuba.

The daily intercourse of life, the just comprehension of common conversation, of literary and scientific journals and even of newspapers, involves a knowledge of Geography; so that it is of daily and hourly use. Indeed, this branch of knowledge is not destitute of noble alliances, especially with astronomy, without some light from which source, it is impossible to understand the theory of climates and seasons and tides, the origin of the zones and of the circles, great and small, and the apparent motions of the sun, both diurnal and annual. This branch of knowledge is almost equally delightful to childhood, youth and mature age, and admits consistently both of abridged and extended investigation.

VII. HISTORY, ANTIQUITIES AND CIVIL POLITY.—The history of our species, involving, of course, their chronology and antiquities, and their civil, religious and military institutions, must ever be a subject of the deepest interest. Indeed, few persons are found, who are indifferent to topics, so fraught with instruction and entertainment ; so pregnant with practical consequences, and so inseparably blended, with our daily employments and interests.

History claims not merely a noble, it asserts a divine pedigree. He who made the world, furnished the history of its origin, and of its early vicissitudes ; he instituted the first social relation, and the earliest patriarchal polity, and he enacted and imposed the primeval laws of social order, and inflicted the first signal penalties for their violation.

Of history, as well as of geography, it may be said, that it is instructive and delightful, equally to the child and the sage, and that it can scarcely be begun too early or continued too late. It exhibits the condition of our species, from their beginning to the existing hour ; it gives notices, more or less distinct and perfect, respecting the monuments of antiquity, whether consisting of physical structures, or of institutions and manners that have survived the ravages of time ; it delineates the modes of civil polity, and the systems of law, under which mankind have either mourned or rejoiced ; and, through the whole of the labyrinth, runs a clew, which conducts us with painful certainty, to the prevailing character of our race. Most governments have been those of tyranny and oppression ; and war, with its rapine, devastation and carnage, has been the great employment of man. As an academical pursuit, history cannot indeed be traced into all its details ; but its elements can be learned ; the outlines of chronology can be taught ; the great principles of law, order and policy can be deduced from facts ; the various species of governments can be delineated, and we shall thus acquire the means of judging, in what estimation to hold our own nation, and our own government and privileges.

VIII. MATHEMATICS.—Among the sciences cultivated by man, one arrogates the proud distinction of certainty, in its results. Founded on intuitive truths, it presents a claim to our confidence, which cannot be questioned, and therefore some men have thought that it is the only *real science*, and that all others, of human origin, are little else than collections of probabilities. If men, of this cast of mind, have been led to undervalue other branches of knowledge, and to demand demonstration on subjects, which do not admit of it; others, of ardent imaginations, impatient of the comparatively slow progress of a mathematical demonstration, have stigmatized the pursuit, as dry and tedious, and worthy only of phlegmatic feelings, and of a plodding intellect.

Both opinions are in the extreme, and therefore neither is just.

The relations of magnitude and number, about which the mathematics are conversant, are attributable to all physical existences, and predicable of space, whether of greater or less extent. In these relations, every one is interested, and were there no other use in mathematics and its connected sciences, than to supply us with precise ideas and terms, for the forms of external things, and with correct expressions for the distances and positions of objects, it would relieve us from much obscurity and confusion. Who, that has once learned the names and definitions of the solids of geometry, and of the relations of lines and angles, would exchange them for the loose and inaccurate language of the common people. But, the study of mathematics, greatly invigorates and sharpens the understanding, by establishing habits of patient investigation, and of exact method, and it conducts us also to many important practical results. The mensuration of heights and distances, the computations of quantity, both superficial and solid, and the linear and angular measurements of perspective, and of navigation, surveying and astronomy, are among its most familiar and obvious applications.

Although the mathematics, in all their extent, variety and applications, may well employ a long life;* and therefore in an academical course, only the elements and the applications of the most important branches can be learned; still, it is highly proper, that in such a course, they should occupy an important place. He that would exclude them, would forego a species of information, and a kind of mental exercise and discipline for which nothing is an adequate substitute; while he who would appropriate to them the greater portion of an education, would form his pupil to general scepticism, (because the system of things around us, rarely admits of certainty,) and to a contempt of the pleasures and advantages, which are derived from the branches of knowledge that cannot be called *exact*.

IX. PHYSICAL OBJECTS—GENERAL VIEW OF THEM.—The physical sciences—those which relate to matter, or in other words to the system of the physical creation, are generally, of acknowledged importance, and most of their branches are, with one consent, admitted into every extensive plan of education.

It is impossible that man should be indifferent to the sensible objects by which he is surrounded. The SUN, the MOON, the STARS, the COMETS, the METEORS, the GALAXY and the AZURE VAULT, arrest the attention even of the rudest savage, and fill his mind with wonder.

THE EARTH itself, the only body in the stellar system, with which man is immediately conversant, contains wonders enough to excite our most active curiosity, and to prompt our most ardent investigation.

THE OCEAN, through successive ages, rolls its untiring waves over three fourths of our globe; its bosom, never, except in its shallows, penetrated by man, is inhabited by countless

* As one long life is indeed said to have been unsuccessfully spent, upon a single problem, the quadrature of the circle.

millions of beings that do not own his sway, and treasures yet untold, are effectually concealed, by the abyss of waters. The ridges, the peaks and the flattened summits of its submarine mountains, form the innumerable islands of the seas and oceans; but no one has descended, down their frightful precipices and declivities, to explore the valleys, the defiles and the undulating and the horizontal plains, which lie between them; nor has any one told us how many submarine mountains have failed, to raise their heads above the waves.* Who can contemplate the ocean without wonder! Agitated by tempests, its conflicting billows rise, in unrivalled majesty; they bear upon their bosom, the well managed ship, or overwhelm her, in the deep; and forming both the bond and the barrier of nations, they separate and connect the most remote countries.

THE LAND, varied with hill, and mountain, and valley, and plain, and river, and lake, presents to the eye, an untiring variety. Adorned with forests, and with the innumerable vegetable tribes, from the minutest lichen or conferva to the royal oak and the cedar of Lebanon, its ruder features are thus softened, by the beauties of a never failing verdure, and abundant provision is made, for the races of terrestrial animals, all of which must, directly, or indirectly, derive their support, from the vegetable creation.

THE ANIMAL WORLD, how extensive! how diversified! It would seem that the Creator delighted in bestowing life; for he has poured forth animation upon every part of our world. The summer insect, scarcely distinguishable from the dust, that floats in the air; the eagle, that soars above the tempest, and gazes intently at the solar blaze; the ani-

* We do not here meddle with geological theories as to the supposed emergence of mountains, nor enquire whether the average depth of the ocean is, as is supposed, ten or twelve miles. If the mountains which rise from its bosom are only as high as the highest that spring from the land, the ocean cannot be less than five or six miles in depth.

malculæ, which owe the proof of their existence to the triumphs of optics; the anaconda, the boa constrictor, the elephant, the whale, the extinct mastodon and the extinct races of gigantic crocodiles,* although occupying widely different places in the scale of existence, are all examples, and for the various purposes of their existence, they afford examples equally perfect, of creative power. MAN, inferior in all his physical energies, to some one or another of the animal races, is still in the aggregate of his powers superior to them all, and *because his Creator has given him a hand and an intellect*, he effectually subdues, and controls and destroys the strongest the fleetest and the fiercest.

THE VEGETABLE KINGDOM, was created not merely to adorn the landscape, to cover the naked hills and mountains, to clothe the plains and the valleys, to refresh the eye, with the delightful picture, which, on a basis of green, presents every other hue of color; it was created not merely to gratify us with the aroma, which floats on the breeze, and bears to our nostrils the diffusive fragrance of fruits and flowers; these gratifications, would be of little real importance, if unaccompanied by capabilities, of substantial usefulness.

The forest, with its princely trees, sometimes the growth of centuries, affords materials for the vehicles that transport us on land, for the machines that are indispensable to the various mechanic arts, for most of the fuel that cheers us in the cold of winter, for the houses that protect us, and for the ships that bear the treasures of commerce and the terrors of war to distant countries and into the solitudes of the ocean.

The vegetable kingdom, too, affords our most important food; the leguminous, the farinaceous, the mucilaginous, and the saccharine seeds, roots and plants are of indispensable

* Recently found fossilized in the lias limestone of England and measuring from twenty to seventy and even ninety feet in length.

importance to man, and many of those vegetable principles which are rejected, as food, are received, as medicine. Even the deleterious principles are often, by skilful administration, made subservient to the support and prolongation of life, and it is highly probable that, but for our ignorance, every plant would be in some way useful.

THE FISH AND THE BIRDS, each in their respective element, would seem to be exempt, in a great measure, from the dominion of man. Had they his intelligence, they would to a great extent be really so, but craft succeeds where force would not avail. The bait conceals the hook, the net bars the only passage for escape, the snare and the trap are hidden or disregarded, the fleeting pigeon, decoyed by his blinded companion (the involuntary and unconscious ally of man,) wheels and lights in unsuspecting security; and even the open warfare of the lance and the harpoon, is waged, where on the part of the victim, there is no suspicion of hostile design. How soon would the irresistible force of the whale, if exerted, thresh in pieces, the stoutest ship!

QUADRUPEDS AND REPTILES are, in general, more within the reach of human sway. Some of them are the real or supposed enemies of man and are therefore the objects of exterminating warfare; their existence is secure only, in inaccessible solitudes, and they always disappear, as human population, and social improvement advance. Excepting the wolf, which retains the dominion of mountain deserts, and of rocky dens, probably no important carnivorous animal, dangerous to human safety, is in possession of any part of Europe. The reptiles are much diminished in number: rarely are they seen in Britain, and never, as is said, in the beautiful Emerald Isle. But, the forests of the other quarters of the globe still abound with powerful quadrupeds; the lion and the tiger leap upon their prey, from the jungles and thickets of Africa, and Asia; and the boa constrictor from the trees; while the brown bear of Missouri and the white bear of

Greenland still wage war with the human savage, equally ferocious with themselves. But, even in the United States, at least in the Atlantic portions, most of the wild, and especially of the ferocious animals, have vanished from our forests, and the *crotalus horridus* (or rattle-snake) although still a tenant of craggy mountains, and unfrequented wilds, is, in a great measure, a stranger to human society.

Among animals, one is the faithful and willing ally of man. THE DOG, whose high value is diminished only by a dreadful disease, of which he is both the instrument and the victim, follows man through all the varieties of his fortunes; he attends him in war and in peace, and in the chase of all the other animals, yields both his speed and force, and his unrivalled acuteness of smell, (the *odora canum vis*,) to the service of his master. He clings to him in the crowd; tires not, when following him upon his longest journey; exults in his favor and kindness; is contented with crumbs and offals, and endures even cruel treatment, without resentment.

Other animals become the servants of man; perform for him astonishing labor; acquire, by domestication, the most perfect mildness and docility, and yield their gigantic strength to the will of their master. The horse, the ox, the ass, the camel and dromedary, the lama and even the elephant acknowledge the dominion of the lord of this lower creation. In vain, would man, at least when encumbered by merchandise, attempt without the ass and the mule, to pass the narrow, rocky roads on the sides of precipitous mountains; without the camel, the Moor would perish, long before he had crossed the great desert, and in the colder latitudes, scarcely could civilized life be maintained, without the fleece of the sheep.

From the worm, which, unconsciously, draws from its own bowels, the glossy fibre, destined to adorn the monarch on his throne, and to decorate the bride at the altar, man obtains his most beautiful covering; man, arrayed in pride by the worm, and soon to become, in turn, his victim.

It admits not of a question, that human life can be fully sustained, by vegetable food and water. The Hindoo demands nothing but this fluid and rice; he has much physical activity, and from the simplicity of his diet, resists the influence of contagion and the gangrenous tendency of the most aggravated wounds, inflicted by a stupid and cruel superstition; his flesh heals kindly, while, under similar circumstances, Europeans would inevitably perish.*

But man is rarely satisfied with vegetable food. Availing himself of his superiority, and of the charter given by God,† he spares no animal which can minister to the gratification of his appetite. The finny tribes are drawn from the waters; the winged nations, that sport in mid air, are decoyed to earth, or brought down by the bow or the gun; the untamed tenants of the forest, free and joyous in their liberty, are smitten by the bolt, which they can neither shun nor repel, and even the patient ox, after toiling through life for his master, and the harmless sheep which clothes him, are, for his support and pleasure, brought to the slaughter. Animal food, reasonably used, contributes, without doubt, to our physical vigor, but man, intellectual and immortal, riots in sanguinary luxury.

THE INTERIOR OF THE PLANET, which is our allotted residence, is not merely *rudis indigestaque moles*; its great masses, the rocks, are arranged in a particular order, and have a peculiar structure and constitution; they are composed of particular aggregations, which give solidity to the whole, and at the same time present innumerable objects of beauty and of utility.

* The Rev. Mr. Ward, the late distinguished English missionary, in Hindoostan, informed the author, that he had frequently seen the Hindoo devotees raised from the ground, by hooks fixed in the large muscles of the back and sides, and in that position whirled violently around, (by means of ropes,) till they were shockingly lacerated; still, in a few days, they would return without injury to their labor.

† Every moving thing that liveth shall be meat for you.—*Genesis*.

THE ROCKS themselves, "the rough frame work of our globe," present to the geologist many a lesson of wisdom, respecting their origin, history and use; their rude battlements piercing the region of perpetual cold, and covered, in many countries, by the eternal snows, whose glassy surface reflects the ineffectual sun-beams, are among the sublimest objects of natural scenery; and their mighty ruins, accumulated for ages in the defiles and valleys, astonish the beholder, by their extent and grandeur. As subjects of architecture, the rocks present the most durable and valuable materials. When man by emulating the mountains, would humbly imitate the Creator, he *builds with stone*: for public structures, there is neither dignity, permanency nor grandeur in any other material; marble, and granite, and sienite and porphyry defy the war of time and of the elements; and the Parthenon at Athens, the pillar of Pompey at Alexandria, the obelisks and columns of Rome, and the scattered and mutilated ruins of Balbec and Palmyra, of Thebes and of Memphis attest, at once, the taste and skill and the barbarism of man, and the indestructibility of the solid materials of our globe.

In its bowels, are contained those more valuable treasures, which, applicable to daily use, afford the most important aid to the arts, to commerce and to domestic life.

The ores of the metals, and especially of iron, lead, copper, tin and zinc; the various limestones, from the coarsest hydraulic cement, to the most beautiful marble; the mines and springs of common salt; the beds of coal and lignite, and those of plaster of Paris, are provided by the Creator, with a profuse liberality, worthy of the giver, and adequate to the wants of his rational and sensitive creatures.

More sparingly, but still in sufficient abundance, has he distributed the precious metals and the gems; the precious metals—the universal representatives of property, and the material of beautiful ornaments, and of utensils, and instruments, both elegant and useful; the gems—the perfection

of the mineral creation, the least destructible, the rarest, the most splendid of natural bodies, but in real utility inferior to many coarse and common substances.

X. PHENOMENA AND SCIENCES CONNECTED WITH NATURAL OBJECTS.—Such are the general outlines of those more important palpable objects, with which man is, necessarily, and constantly conversant. From the contemplation of them he cannot, if he would, be wholly withdrawn, nor can he, while contemplating *physical existence*, be indifferent to THE PHYSICAL PHENOMENA which above, beneath, around, are perpetually exhibiting the relations of material things, and the sustaining and directing energy of the Creator.

In ancient times, every thing relating to natural bodies was included under PHYSICS, and the term therefore comprised NATURAL HISTORY, NATURAL PHILOSOPHY and CHEMISTRY. Since the more extended cultivation of natural science, and particularly since the time of Bacon and Newton, the external appearances of natural bodies have been included under NATURAL HISTORY, their analysis and composition are assigned to CHEMISTRY, and their mechanical laws and affections are left for

1. NATURAL PHILOSOPHY.—This science occupies itself with the affections and relations of the bodies of our own planet, with the physical laws of light, heat, magnetism and electricity, with the weight and pressure and movement of fluids, both gross and aerial, and in short, with all that is not included in the two other great divisions of natural science. Natural Philosophy is a science of high import ; it is in every university, a regular branch of education, and in every enlightened country, an object of diligent research. It is founded on observation and experiment, but since the time of Newton, the application of the mathematics to these researches has given them both dignity and certainty. Natural Philosophy comes clothed with so many attractions, that there are few minds which are not powerfully arrested by its discoveries and regaled by its phenomena.

The pupil learns, with pleasure and surprise, that the same power which retains Jupiter in his orbit, precipitates a falling drop; that a feather, a balloon and a ship of the line are floated by statical pressure; that this principle causes a narrow column of water sustained in a tube to raise a weight many thousand times greater than its own; that it causes a cascade to fall through the atmosphere, and still imparts to the atmosphere, in its turn, the power of raising a column of water in a pump, and that it exerts a dominion uninterrupted and perfect, over atoms and planets, over systems and worlds. It is seen by the learner, that the mechanical powers, so indispensable to our existence and efficiency, and that the motions of animals are dependent upon similar principles, and gravity is not unfrequently the immediate agent.

The phenomena of LIGHT are among the most beautiful and instructive of those belonging to Natural Philosophy. The illusions of the magic lantern and phantasmagoria amuse our childhood and instruct our maturer years. The rainbow is a splendid example of the decomposition of the solar light, effected by the refractive power of the drops of water; still, magnificent and beautiful as it is, it excites perhaps less astonishment in the beholder than the colors exhibited by the common prism in a darkened room, where the iris, although very small, compared with the bow, is more intense and is brought within our reach. The astonishing results produced by the solar focus, in which the beams that a moment before cheered and warmed an insect, now melt and dissipate metals and stones; the surprising and beautiful effects of the common, the lucernal and the solar microscope, in whose fields of vision motes become beams, and animalculæ, giants; the wonderful illustrations of the eye, on whose retina, either uncovered by dissection, or imitated by art, are seen painted, distinctly, and yet in all their varieties of color and of form, the fields, the groves, the sky and the faces

of men and all the objects that surround us; the powers of the telescope, by which we penetrate into the awful darkness of space, and in some measure rend the veil that covers the heavenly bodies; these are a few of the wonders which natural philosophy teaches respecting light, that incomprehensible emanation, without which the face of the creation would become cheerless and desolate, and animated beings would soon dwindle and die.

THE ATMOSPHERE, in tranquility, is little regarded except as affording the means of comfortable respiration to the whole animal world; but, disturbed in its statical pressure, by the influence of heat, it generates not only land and sea breezes, and monsoons, and trade winds, but the hurricane and the tornado. Navies are overwhelmed in the waves, the oak and the cedar are prostrated, and man and his works, his towers of strength, and his pinnacles of pride are levelled with the dust. The same atmosphere, although invariably the residence of the electric fluid, exhibits, only occasionally, decisive proof of an energy, which pervades the material world. Excited by causes, which, except in their proximate operation, are unknown to us, the electric fluid fills the atmosphere with thunder and lightning; it flashes from the black clouds, in which, with wind and rain, it musters its tremendous power; and its forked arrows, darting from heaven to earth, —from earth to heaven, shew in lines of intense brightness, where the dreaded bolt has been directed. It was reserved for Dr. Franklin to prove, that the lightning of the atmosphere is identical with the sparks which are obtained from the friction of glass or resin, or even from the dry fur of a living or dead animal, from our own dry and warm apparel of silk or woollen, and from many other sources. In short, we now know, that all things are full of the electrical influence, that we can bring it down by kites, metallic rods and wires from the clouds; that we can evolve it by our machines of glass and metals, and that by certain ar-

rangements of metals, acids, and other substances, we can produce it at pleasure, (connected more or less with the other imponderable fluids,) in entire independence of the weather, and of the state of the atmosphere. In the last remark it will be perceived, that we allude to Galvanism. If not the most striking, certainly the most interesting thing, that belongs to electricity is the exhibition of attraction and repulsion, which is inseparable from its excitement.

Although the experiments, exhibiting these facts, are sufficiently curious, the importance of the subject has, only within a few years, been perceived in its full extent ; for it is now believed that the particles of matter are constantly under the influence of these attractions and repulsions, and that they are producing, without cessation, decompositions and new arrangements of matter.

Associated, every where, with electricity, HEAT both modifies its effects, and produces peculiar phenomena. The mild radiations of the sun, and the gentle fluctuations of temperature are subjects of common experience, and excite no particular surprise. But the amazing energy of VOLCANIC ACTION, although on the surface only local and occasional in its operation, far surpasses every other example of natural heat. Science is now in a condition to reason, with considerable probability, as to the causes of volcanic heat, and still more, regarding those of the accompanying phenomena of earthquakes: but leaving these for the present out of view, our attention is arrested by the grandeur of the events, associated with volcanic agency.

The shaking and rocking of the ground, not only in the immediate vicinity, but often in distant countries, the subterranean noises, like internal thunder and the sound of the rending of the solid strata, the violent emission of smoke, steam, ashes, sand, ignited stones and rocks, and eventually of the current of lava which flows in a sluggish stream of fire down the mountain and over the nether country ; the

overthrow of the structures of man, beneath the lava and ashes ; the vivid lightning and deafening thunder in and above the crater ; the violent flux and reflux of the tides and the strong agitation of the sea, alternately inundating and draining the adjacent shores ; the deluging showers of rain and mud, and the delusive periods of repose, between the eruptions, sometimes extending to years, and centuries, are among the principal circumstances, which characterise volcanos.

ATTRACTION AND REPULSION, although less obvious than some of those phenomena that have been mentioned, are undoubtedly, more important in relation to the system of things than any or all other natural causes and events.

Gravitation is the bond which connects, equally, the greatest and the minutest parts of our system. Every particle of matter gravitates towards every other ; every mass, however large, is attracted by every particle however small ; every member of our system, and every system, in the systems of systems is affected, reciprocally, by every other : projectile power, or immense distance and counterbalancing attractions keep them from rushing together in ruinous collision ; and the whole creation of matter is afloat in space, suspended and sustained by the energy of almighty power.

It would be foreign to our present purpose to designate the details of the various kinds of attraction—the electrical, the cohesive, the chemical, and the magnetic.

The magnet is universally known, and by its aid we traverse the ocean and pathless deserts. It presents the most striking and familiar example of repulsion, a power, which, springing from various causes, and operating under various forms, is every where active around us, although unseen. We do not certainly know that magnetism can be permanently attached to any other substances than iron and nickel,*

* Some add cobalt.

although we can no longer entertain a doubt that it holds a permanent connexion with heat, light and electricity.

Attraction is only a name for an unknown cause, of which we have no other knowledge than that it depends on the will of God. Mysterious indeed it is, but it is not more so than the connexion of our intelligent minds and of our affections, with our living bodies. An omnipotent and all wise Creator can endue matter with any properties that he pleases to bestow, and there are, undoubtedly, many possible qualities, which he has not bestowed, and many actual ones, which we have not discovered.

ASTRONOMY examines the parts, the construction and the relations of all the bodies in the universe. It has taught us that the diffuse light of the Galaxy is composed of the mingled effulgence of innumerable stars, each of which is, probably, the centre of a system, and the continually increasing power of *penetrating into space*, acquired by the modern improvements of the telescope, evinces that we have only begun to number the stars, and that we shall never be able to call them all by their names. But we have measured the distances and the dimensions of the planets and the periods and the rapidity of their revolutions; and we have ascertained their absolute and relative weight. We know not where discovery will stop; the noble science of astronomy is now cultivated with an ardor not surpassed even by that of the age of Newton, and with means far superior. Innumerable discoveries of new stars have been made; it is even proposed to divide the heavens into compartments, and to allot each to an astronomer of eminence, that the observations may be more precise and accurate; already it is ascertained that a part of the fixed stars have a revolution indicating the movements of the members of particular systems. This is true, especially of what are called the double stars, and the sublime, the overwhelming conception is entertained, that the whole stellary system, with its myriads of planeta-

ry worlds, revolves in the course of ages around a common centre.

Astronomy is, not without reason, regarded, by mankind, as the sublimest of the sciences. Its objects, so frequently visible, and therefore familiar, still do not lose their dignity, because they are always remote and inaccessible. From the sun, that splendid emblem of the Godhead, to the feeblest star that twinkles in the heavens, and represents the humblest intelligence of the spiritual world, all is full of dignity and beauty. The heavenly bodies seem, as if they held a close connexion with the Deity, and as if their shining orbs must be the habitations of angelic beings. The starry heavens have, in all ages, fixed the attention of mankind; the shepherds of Egypt and Arabia watched the revolutions of the Bear, and gazed on the beauties of Orion and the splendor of the comets; the royal poet exclaimed, When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained: what is man, that thou art mindful of him, and the son of man, that thou visitest him! The eyes of the vulgar and of the learned are almost equally arrested by some of the phenomena of the heavens. The navigator, as he crosses different latitudes, sees stars and constellations sink and emerge; passing the equator towards the south, he watches the extinction of the polar star in the northern ocean, and sees new combinations of stars and new individuals arise, while others disappear. Although Newton, a century ago, unfolded the structure of the universe; Herschel, La Place, La Lande and other distinguished astronomers have continued to enlarge our knowledge of the heavens, and Chalmers, with his own peculiar eloquence, has arrayed astronomy in new attractions, by connecting its physical features with our moral instruction.

The practical applications of astronomy, in determining the latitude and longitude, especially at sea, are highly important; the exact calculation and prediction of some of its more

striking phenomena have removed the superstitious dread of eclipses, and substituted a rational comprehension of their cause; while the transits of the planets and the measurement of arcs of great circles of the heavens in different latitudes, have been thought sufficiently important to justify voyages and journeys to the Orkneys, the Hebrides and the northern polar circle, to St. Helena, the Cape of Good Hope and the islands of the Pacific. It may be mentioned also, without impropriety, that the observation of the heavenly bodies is a rational source of amusement. In a fine night, the telescope, although not like that of Herschel, of immoderate size and expanse, is an interesting companion, and we contemplate with delight the mild splendors of the evening star, the fiery face of Mars, the silver orb of Jupiter and of his attendant satellites, and the incomprehensible rings of Saturn.

2. NATURAL HISTORY describes the external appearance of all natural bodies. It embraces a great number of divisions, of which the principal are Zoology, Mineralogy and Botany.

ZOOLOGY, which includes the whole animal world, comprehends also a great number of subdivisions, e. g. ornithology, ichthyology, herpetology, entomology, conchology, &c. As it is conversant about animated beings, it inquires also into their habits, their food, their reproduction, their decay and their death. Strictly, man is at the head of this department of Natural History. Zoology begins with man and ends with the snail and the oyster, and in its course it embraces the elephant and the mouse, the lion and the ground mole, the whale and the earth worm, the eagle and the gnat.

Among the reptilia, some are of enormous size, as for instance the boa constrictor and the anaconda of Surinam. Among the amphibia, the fishes and the mammalia, gigantic animals are found; the whale, the larger seals, called by the sailors sea lions, sea cows and sea horses, and the rhinoceros,

the hippopotamus, the wild buffalo, the camelopard, the camel and the elephant, are signal examples. In zoology, living animals are of course more interesting and more instructive subjects of study than dead ones, however well preserved.

A menagerie, or a collection of wild animals, detained in confinement, is a customary appendage of royalty; these exhibitions, as regards especially the larger and more perfect wild animals, afford very fine opportunities for the study of zoology. The traveller finds the panthers and the elks of America, the rein deer of Lapland, the lions, the camelopards and the zebras of Africa, and the royal tigers, the hyenas and the elephants of Asia, torn from their native forests and dens, and ingloriously caged in the apartments of Exeter 'Change, of the Tower of London, and of the Garden of Plants of Paris.

But, where all opportunities from museums, whether of dead or living animals, are wanting, zoology may still be studied, with good advantage, by the aid of the numerous works on this science, illustrated as most of them are by accurate engravings. The animal races of fish, fowl, insect, reptiles and quadrupeds share the physical bounties of the Creator with man, and, in spite of his art and power, still hold the dominion of the greater part of our globe.

MINERALOGY AND GEOLOGY include all that relates to the mineral constitution of our planet, its atmosphere and various gases, its waters, its metals, its salts, its combustibles, its ores, and its earthy combinations. The study embraces not only mountains and continents, but the pebbles under our feet, the sand on the shore and the dust that is borne on the winds. It attempts to account for the origin and causes of the present state of things, and it contemplates the impending changes, decay and dissolution of the firm substratum of our globe, the basis on which live and repose the various races of animals and vegetables, and from which,

and its attendant waters and atmosphere, they draw their aliment. Minerals, although to some extent constantly before us, are, for the greater part, far more inaccessible than vegetables and animals. Many of them are drawn from the recesses of the earth, from the caverns and mines remote from the light of day. In this department then, although something may be done with the aid of such things as we can every where obtain, still, a cabinet or museum is peculiarly necessary, and, as this study is acknowledged to be both important and interesting, collections in mineralogy are found in colleges and universities more generally than any other subjects of natural history. They have the very important advantage of being, with few exceptions, not liable to destruction, nor to any spontaneous changes. They need no preparation, but when detached from their native situations, and reduced to a proper size, are ready for the museum. This department of nature affords much of the wealth of nations, many of the comforts of civilized and polished society, nearly all the instruments of physical and philosophical research, and most of those of the ornamental and useful arts. Civilization, social refinement and science cannot exist where the mineral kingdom is not explored and understood, and especially where iron and some of the other metals are not known and used.

Although no aliment for living beings is obtained from this kingdom, very important remedies are derived from it, especially from several of the earths and metals. Plants and animals are probably more attractive to the eyes of most persons than the greater part of minerals; still, among these last, are found objects of extreme beauty, crystals whose polish and whose form rival the finest works of art, colors that are not surpassed in intenseness and brilliancy by the flowers of a green house, and gems which have ever been selected from all the objects of creation to adorn the royal diadems and the imperial crowns; and to afford striking rhetorical symbols, for the most exalted virtues.

GEOLOGY, which reveals to us the actual structure of the globe, and the natural position, relation and associations of its productions, affords important light in the research for useful minerals; it abundantly confirms the truth of the Mosaic account of the creation, and of the succession of its various epochs, and it exhibits, in the arrangement and contrivance of the mineral strata, decisive proofs of the power, wisdom and design of its author.

BOTANY, is the natural history of plants. It is a beautiful and eminently useful branch of knowledge. It is constantly extending its researches and adding new species to the great number which have been already discovered.

The loftiest forest tree and the humblest shrub are equally within its domain, and every climate, and every continent, country and island, are visited for the discovery of new species. The plants that grow in mountainous countries indicate, with great accuracy, the climates that belong to the different elevations; the plants and fruits of tropical regions may grow at the foot, and the stunted evergreens of the polar circle may crown the top of the same lofty mountain.

In this elegant department of knowledge, a sufficient number of its subjects is scattered every where around us, to afford the means of comprehending the outlines of the science and of prosecuting it with considerable advantage. Its dried specimens are preserved with incomparably more ease than those of animals, and it is thought to be an object worthy even of princely munificence to found collections of living plants, and to preserve them in the Botanical Gardens, as is seen in the royal establishment of Kew in England, and of the Garden of Plants in Paris. But spirited individuals* have, either by their own efforts, or by the as-

* As Mr. Roscoe and Dr. Currie of Liverpool, Dr. Hope of Edinburgh, Mr. Bartram of Philadelphia, and Dr. Hosack of New York.

assistance of private citizens, like themselves, formed botanical gardens, of signal beauty and utility. No species of museum is more beautiful and attractive. To wander, amidst the fragrance, the flowers, the fruits, and the verdure of every clime, and among plants of every size, from the parasitical mosses to the naval pine, is to view, in one grand perspective, the vegetable glories of the world. The study of the science is also thus facilitated, in a surprising degree, and the botanical student finds, within the bounds of at most a few acres, the plants, to have seen which, in their native soils, would have demanded a life of adventure. The vegetable kingdom affords most of the food of men and animals, many medicines, and many materials for the arts.

3. CHEMISTRY.—The remaining branch of science relating to natural bodies, begins where Natural Philosophy and Natural History stop. The gleanings of its early history may be found in the prefaces of the various elementary works on chemistry. Some knowledge of chemical arts is coeval with the earliest stages of human society, and it has happened with this, as with other branches of natural knowledge, that many facts were discovered, and accumulated, in the practice of the arts, and in domestic economy, long before any general truths were established, by a course of inductive reasoning, upon the phenomena.

The arts are all either mechanical or chemical, and not unfrequently both are involved in the same processes. The practices of the arts may be regarded as experiments in natural philosophy and chemistry. The object of the artist is usually gain, but he, or any other person, who views the facts correctly, may reason upon them advantageously, and thus obtain important instruction.

Glass is a chemical compound, usually of siliceous earth and fixed alkali, or at least of alkaline or saline and earthy materials. These, after being duly proportioned, are combined by the effect of fire, and various adventitious matters are

added, to impart color or to discharge it, to increase the density, or to diminish the hardness, or for various other purposes.

The production of the material of the glass depends therefore upon chemical principles, and is, thus far, a chemical art. But, the fabrication of the vessels depends upon mechanical causes, principally the breath of the artist, injected through an iron tube, to which the melted glass is made to adhere. The subsequent cutting, grinding, and polishing of the glass are also mechanical, and thus glass is a production both of chemistry and mechanism.

Soap (except the mere act of mingling the oil and the alkali) is a production of chemistry alone; a watch is a result of mechanism, but the metals of which it is made are prepared by chemistry and mechanism united; wool is carded, spun, woven, fulled and sheared by mechanical means, but it is scoured and dyed by chemical means, and thus through a multitude of instances, the number of which it is not at present necessary to enlarge, the purposes of society are accomplished, by the application of the principles of one or of the other, or both of these sciences.

It would exceed our limits to trace the progress of chemistry from age to age; to unfold the delusions of ALCHEMY, whose object was to discover the philosopher's stone, an imaginary substance, which, it was supposed, would convert the baser metals into gold and silver, and thus enrich, to any desired extent, the favoured devotee: or, to speak of the equally delusive pursuit, after the GRAND CATHOLICON, or universal remedy, which was to remove every disease; to avert death, and confer terrestrial immortality upon man; or to mention the equally imaginary ALCAHEST, or universal solvent, whose power it was supposed nothing could resist. The alchemist indeed imagined, that these miraculous virtues resided in one and the same substance, and during the dark ages, most of the cultivators of what was then called chemistry, smitten with the delirium of alchemy, pursued

their occult processes, in cells and caverns, remote from the light of heaven, and wasted their days and nights, their talents and their fortunes, in a vain and impious pursuit. The alchemist however accumulated many valuable facts, which have been employed, with good advantage, in laying the foundations of modern chemical science.

This science, considered as a collection of elementary truths derived from the study of facts, can scarcely be referred to a period much beyond the commencement of the last century, and its principal triumphs have been achieved, since the middle of that period. It would be premature, to detail, on the present occasion, the particular discoveries, which, like stars, rising successively, above the horizon, in a dark night, have irradiated the hemisphere, in rapid succession. Those discoveries, their periods and authors will be mentioned, in giving the history of each particular substance. At present, it would not be proper to attempt any thing more than to convey to those to whom the subject may be new, a general conception of the nature, extent and objects of the science of chemistry, reserving the details for the time when they will be both the most intelligible and the most interesting.

DEFINITION.—CHEMISTRY IS THAT SCIENCE WHICH INVESTIGATES THE COMPOSITION OF ALL BODIES.*

Remark.—The object of Chemistry being not only to ascertain the composition of all bodies, but to form all possible combinations; it includes of course all possible decompositions, and the laws by which both are governed.

Natural Philosophy examines all those properties which are exhibited by the body in an undecomposed state. Chemistry taking into view the properties discovered by Natural Philosophy, begins its appropriate work where the sister science stops.

* For various definitions the student may see the principal authors, Thomson, Fourcroy, Henry, Murray, La Grange, Thenard, Davy, Brande, Turner, Hare and others.

The distinction between chemistry and natural philosophy is illustrated by the familiar examples of

1. *Water*,
2. *The atmosphere*, and
3. *Gunpowder*.

Thus, water is composed of the bases of two gases, the air of at least two, gunpowder of combustibles, metals and the ponderable part of gases united.

Natural History, *Natural Philosophy* and *Chemistry* are all necessary to complete the scientific history of any thing.

Natural History explains the external appearance of bodies;

Natural Philosophy the mechanical properties ;

Chemistry the constitution.

This general position is easily illustrated by reference to *amber*, *coal*, *calc-spar*, *fossil salt*, &c.

Chemistry is distinguished as *an art* or a collection of arts, from *chemistry* as a science : the former is empirical, the latter is guided by established principles.

Chemical arts are numerous ; besides those of *glass* and *soap-making*, there are those of *pottery* and *metallurgy* ;

That of *Dyeing*, by affinity of coloring matter for fibre, or for the mordant, or for both ;

The fermentation of *cider*, slow and rapid, regulated by heat and by cold ; so of *wine*, *perry*, *metheglin*, *porter*, *beer*, &c. carbonic acid gas being evolved and alcohol formed.

Leather is formed from skins and tannin contained in the astringent vegetable, the tannin of the latter uniting with the gelatine of the skin ;

Bread by a peculiar fermentation ; its sourness, owing to excessive fermentation, is corrected by an alkali.

Ink ; the theory of its formation is, that the astringent principle unites with the oxide of iron, and gum Arabic or sugar suspends the precipitate.

The burning of lime consists in the expulsion of the carbonic acid, by heat; the acid gas forms nearly one half of the weight of the limestone, marble, chalk, &c.

The reason why *art* and *science* mutually aid each other, is, that art furnishes hands and science eyes; science without art is inefficient, art without science is blind.

The chemist must understand the *principles* of the chemical arts, and the more of the practice the better.

Chemical artists should understand the science, at least of their own arts, and practical knowledge is of course indispensable.

Not satisfied with the knowledge of the external properties and the mechanical relations, which are unfolded by Natural History and by Physics, but, taking them into view, and retaining and using their principal discoveries, chemistry proceeds to investigate the hidden constitution of every species of material existence, in earth, sea and air, and of the various living beings by which these regions are occupied.

Look upon the principal objects around us, the *water*, the *earth*, the *air*, the *fire*; the four famed elements of the ancient school: they have all yielded to the scrutiny of a rigorous analysis, and water, bland and simple as it seems, contains two most extraordinary bodies, perfectly at variance with its own properties, and with those of each other; burning, when mingled and ignited in large quantities, with loud and rending explosion, and in a small stream, with an uncontrollable heat, which melts and dissipates the firmest substances. The inquisitive pupil, may be incredulous when it is asserted that water, whose eminent prerogative it is, to extinguish fire, and to save burning cities from destruction, contains the principles of heat and of the fiercest combustion. We can now only assert that it does indeed contain them, but the proof of the fact, will be exhibited hereafter.

The air, the pabulum of life to the whole animal and vegetable creation, mild and negative like water, is not *simple* but contains incidentally many bodies,—essentially however only two ; one of which and that, constituting four fifths of the whole, is, and was intended to be, in a high degree noxious and even deadly to animal life and fatal to combustion. If the pupil enquires why the air does not destroy life instead of invigorating our frames, and extinguish instead of inflaming combustion ; chemistry replies that the prevalent noxious principle of the air is balanced by a life-and fire-sustaining principle, too vigorous to be trusted alone, and therefore, diluted exactly to the proper degree, by an opposite principle, both being, by another extraordinary provision, sustained, in exact and unvarying proportion, and thus producing a salubrious and unchanging atmosphere.

The earth, under our feet, the soil, the sand, the gravel, the firm substance of the rocks, is not simple. In this ancient and supposed element, we have a double complexness. The one imagined, simple earth contains at least nine, and each of these is again complex, containing for one principle, an aerial fluid, the same that exists both in water and in the atmosphere, united to nine or ten varieties of metals or combustibles none of which are known in common life. If the pupil does not pronounce the statement absurd, he may very probably exclaim, that it is incredible that the earth, sand, soil, gravel stones and rocks are composed of air* and metals. He may demand that he who believes that there is air in stones should tell us why they are so heavy, and if there is metal in them, that he who asserts it should even melt it out of these bodies, which our fires will not melt at all !

When the pupil becomes acquainted with the wonderful effects of chemical combination, he will not think it strange that half the weight of marble is carbonic acid and that met-

* Strictly its ponderable part.

als, when combined with a particular variety of air, resemble very exactly, the earthy substances.

Light is contained in fire as well as heat, and therefore it is not quite simple, unless fire and light are indeed varieties of one and the same thing.

Modern research, (and this subject belongs as much to general physics as to chemistry,) has proved, that, besides light, in its seven prismatic colors, which is contained in the solar beam, there is also, in this emanation, an opaque, radiant principle, which accompanying light and heat, neither warms nor illuminates, but acts to decompose certain chemical compounds; that there are opaque rays which warm but do not illuminate, and illuminating rays which are cold to the sense of living animals, but impart to the universe its splendid drapery of colors, and that, associated with one or more of these emanations, there is a surprising power, which imparts magnetism to a needle, and gives it the properties of the loadstone.

If the pupil be not now so confident in his own experience, as to pronounce this statement absurd, or incredible, all will agree with him that the facts are indeed wonderful! But, we have used the word element without defining it.

An element is an undecomposable body—it is therefore simple, or in other words not reducible into any other form of existence. We must however, carefully distinguish, between *real elements*, and those which are so only in relation to the present state of our knowledge. When modern science speaks of a body as elementary, it intends nothing more, than that it has not been decomposed. It is therefore simple as far as we know, but we cannot say that, by future efforts, it will not be decomposed. Although we have no reason to doubt, that there are *real elements*, we cannot say, that we are certainly in possession of any one element. Nothing but a direct revelation would give us this assurance, and then our belief would rest, like

that of religion, not on philosophical proof, but on faith. Perhaps it is of no practical importance that we should have such a communication. It is perfectly safe to reason upon bodies as elementary, until they are proved to be compound. Iron as far as we know, is a simple body; we cannot exhibit it in any simpler form; all we can do, is to alter its figure, to divide and subdivide it by filing and other mechanical operations, which only diminish the size of its parts, without at all changing its nature. But iron rust, or the scales which fly off, when red hot iron is hammered, are not simple; they consist of iron, combined with one of the principles of the atmosphere; we can exhibit these substances in a simpler form—the iron, which they contain can be separated from the aerial principle, and both can be exhibited apart, and thus the proof will be complete—red lead and red precipitate are still better examples, because the former can be partially, and the latter wholly, brought back to the condition of metals by simply heating them.

The four ancient elements, earth, air, fire, and water were assumed at hazard, because they are so conspicuous and important; the conception was grand and beautiful but it was wholly erroneous.

Instead of four elements, we have at the present time not less than fifty; nearly four fifths of which are metals, the remainder are chiefly combustibles and bodies, which, combining with combustibles and metal with peculiar energy, are called supporters of combustion.

One or two other principles are unique in their properties and are not assimilated exactly with either of the other classes—our simple bodies then are

- | | | | | |
|--|---|---|---|--------|
| 1. Metals, about | - | - | - | 40* |
| 2. Combustible not metallic, | - | - | - | 6* |
| 3. Principles or supporters of combustion, | | | | 2 or 3 |

* It is perhaps doubtful where some of these bodies ought to be classed—whether among metals or combustibles.

4. One body, or possibly two of a character midway between the two last.

5. Imponderable bodies, light, heat, electricity, magnetism, &c.

The great object of chemistry is to display the properties of these elements, the mode and energy of their action, the laws by which it is governed, the combinations which they are capable of forming, and the properties of the resulting compounds. This statement, obviously, includes all bodies natural and artificial. There are many chemical compounds made by art, which, as far as we are informed, do not exist in nature, and there are many natural bodies which art has not yet been able to produce.

The philosophical chemist is held responsible to explain the inherent properties of the elements, and the constitution of the intermediate or proximate compounds of the whole material world, as far as it is tangible by man. Of the constitution of the planetary and stellary bodies, we have no knowledge except from the hints that are afforded by the occasional projection to our earth, of stony masses, severed by explosion from luminous meteors or fire balls, which occasionally pass, with great velocity, through our atmosphere.

It will be easily understood, that the philosophical chemist undertakes an arduous and responsible duty, involving much manual skill and labor and mental effort, but the reward is rich and gratifying.

The veil is withdrawn from the face of nature, and a constitution of things, not at all suspected by those ignorant of this science, is unfolded.

Like those, who, in tales of romance, are supposed to drop suddenly, through concealed spring doors into subterranean halls and palaces, rich in the garniture of fancy, and filled with the spells of enchantment; the pupil in this science discovers that he has, all his life, walked unconsciously over hidden pitfalls; that like a child scattering sparks among

gun-powder, he has often been sporting with dangerous elements, and that, with all his curiosity and intelligence, he has known only the surface of things. He finds, every where, innumerable applications of his knowledge to purposes of practical utility, to those of domestic life, to the arts which enrich and adorn society, and to the illustration of the wisdom, power and goodness of that great being, whose pleasure called the physical universe into existence.

To exhibit the proof of these statements, even in outline, would require a distinct recital, and might well occupy a treatise. But many opportunities will hereafter occur when these truths may be concisely enforced, without encroaching, too much, upon the proper duties of elementary instruction; for, it must be observed, that it is quite one thing to discover and to teach elementary truth, and quite another, to point out its utility and application. A happy combination of both produces the most useful and gratifying instruction.

It would be premature, to attempt, at this time, to exhibit the nature of the evidence upon which chemical deductions are founded, and the mode in which the study and exhibition of the science are prosecuted.

It is sufficient to say, that like the other physical sciences, chemistry derives its evidence, from experiment, and observation of natural facts; but as a great proportion of the facts are such as do not occur in common life, and still, as they all have their foundation in the constitution of things, it becomes necessary for the philosophical chemist to perform a great number of experiments, in other words to exhibit a great number of facts, for an experiment is nothing but the exhibition of a fact, according to natural laws, which it is not in our power either to create to cancel or to modify. Hence, the necessity of becoming well acquainted with those laws. Whenever all of them shall be fully understood, then chemistry will have reached its perfection, and in rela-

tion to the science, the greatest service which we can perform, is to extend and perfect its general laws. At some future day, facts will be viewed in a more general light—it will not be necessary to study them so much in detail as now; selections will be made to illustrate general principles, and thus chemistry will be assimilated to Natural Philosophy.

Chemistry may be regarded in three views, all of which are interesting and important.

1. As a branch of general Philosophy.
2. As a school for the chemical arts and for many of those of domestic economy.
3. As an important auxiliary to the profession of medicine and to pharmacy.

In accordance with all these views it is now ardently and perseveringly cultivated, in every enlightened country. In every university and medical school; in every college; in many academies; in voluntary associations, in larger and smaller towns, supporting Lyceums and Athenæums; in popular courses, sustained by private individuals; and even in manufacturing establishments, fostered by the zeal of the operative artizans; chemistry, with the sister science, natural philosophy, is assiduously and advantageously, cultivated. It would now be as disreputable for any person, claiming to have received a liberal education, or to possess liberal knowledge, to be ignorant of the great principles and of the leading facts of chemical as of mechanical philosophy. Many intelligent artizans now resort to philosophical lecture rooms, to learn more perfectly the principles of their respective arts, and the great familiarity with the practical facts of their callings which they, of course possess, and ordinarily in a degree superior to that attained by teachers of science, enables them to apply with great advantage the general principles which they acquire.

Domestic economy is greatly benefited by a correct knowledge of the principles of natural and especially of chemical

science. Besides instances that have been already named—the combustion of fuel; the equal and economical distribution of heat for the arts, for preparing food and for warmth; the economical and effectual production of artificial light; the preservation of delicate fruits and of their extracts or jellies; the preparation of food by steaming, boiling and roasting; the extraction of animal gelatine; the manufacture of starch; the separation of butter and cheese from the milk; the bleaching and dyeing of stuffs and many more domestic arts depend upon the principles of science, and chiefly upon those of chemistry. It is true that these things are accomplished, with more or less skill, by persons unacquainted with science, but there can be no doubt that they would be better and more effectually done, were both masters and mistresses enlightened more generally in the principles of science. To insist on no other instance, there is no doubt that in the common modes of using fuel, a large part is wasted, and that part skilfully applied would be more effectual than the whole as it is in most cases actually used.

There is now, generally, but one opinion as to the importance of chemical science to the profession of medicine. This opinion is sufficiently evinced by the fact, that there is no medical school in which chemistry is not taught, nor any medical examination in which this topic is omitted. It is true that medicine may be practised, empirically, by those who understand neither the structure of the human frame, nor the nature and properties of the substances, which they administer. But who would choose to trust such men; or those who, equally uninformed, as to the nature of things, mix, compound and vend, by precept and example alone? Both may indeed do it successfully, but it is travelling blind-fold, and leading others at the same time, and the ditch may be nearer than we are aware of. Medicine and pharmacy both need the aid of scientific chemistry; then they can pro-

ceed with intelligence and confidence—they can shun and rectify errors, discard abuses, and add new resources to the healing art. They will avoid mixing inconsistent, warring, and mutually subversive ingredients ;—they will reject the spurious and inert—scrutinize with skill and knowledge the genuineness of medicines, and avoid painful—sometimes fatal mistakes.

The principles of natural and experimental philosophy also should enter into the education of a medical man ; and if he have not been already initiated into these elements, he should neglect no favorable opportunity of acquiring them. Mechanical and chemical principles are constantly brought into view, along with the principle of life, in reasoning upon the phenomena of the human frame, and in surgery, a skilful mechanism and the correct knowledge of mechanical principles are of the utmost importance. A knowledge of natural philosophy should every where be—and in some seminaries it is—an indispensable qualification for medical privileges and honors.

The enlightened medical man will regard his profession in a higher view, than as being merely a business, by which he may live. The true physician is a man of extensive scientific acquirements. No other profession demands so much scientific knowledge ; and when this is possessed, by a man of powerful and ardent mind, and united to habits of persevering and industrious exertion, the medical man may become entitled to a distinguished rank among philosophers. Probably science is more indebted to medical men than to those of any other profession. Every young man, who, with competent talents, enters upon the study of this profession, should aim at acquiring enlarged views of general as well as of medical science, and should endeavor to add something to the common stock of knowledge.

The physician, who possesses the true spirit of his profession, will aim at a still higher excellence, that of being a

good man. Familiar in the confidence of families, having access to all, in the hour of sorrow, and of tenderness, and weakness, he is, if a virtuous and amiable man, regarded as the common friend of mankind. It is however in his power, to sow moral contagion, or to diffuse the happiest influence. No man except a clergyman can do so much good, no man whatever, can do so much harm !

In this introductory sketch of some of the outlines of human knowledge, we have allowed ourselves to keep distinctly in view the important truth, that moral beings cannot cultivate even physical science, without imparting to their labors a moral bearing ; and that we are responsible for the use which we make of natural science.

If it is interesting to us to know the character and will of the supreme creator and governor of the universe, it is important also to realize that there are but three sources of information—his works, his ways, and his word ; as these three correctly understood, form one harmonious system, it is impossible, fully to understand the relations of moral beings to either of the great members of this system, without some considerable knowledge of them all ; and to him who alone perfectly comprehends the whole, both in all its extent, and in all its details, every thing in nature, in providence and in revelation, is consistent and beautiful.

In concluding, we may observe for the sake of the general student, that

LITERATURE adorns and illustrates science, adding much to its attractions, and to the method, perspicuity, and effect of its researches and communications. It cannot be entirely neglected, by any one who would claim an elevated rank in physical science. The most valuable researches and discoveries are, to a degree, disgraced, by being clothed in a coarse and slovenly style, and communicated without good arrangement, and without logical clearness and precision. It sometimes happens, that able philosophers and mathe-

maticians are accomplished scholars, and then the utmost finish of beauty and elegance is given to the solid structures of physical science.

No one who has had opportunity to appreciate their attractions, and their utility, can be insensible to the advantages and pleasures of polite literature, and of miscellaneous knowledge which present a rich field for investigation, and afford ample remuneration to the literary devotee.

But—*ars longa, vita brevis*, meets us at every turn, and, although the general student, in the regular progress of a university education is of course, made acquainted with the outlines of the principal branches of human knowledge; in after life, we are obliged to say, *non omnes omnia possumus*, while reluctantly giving up the rest, we select and pursue some one art, science or practical profession.

But, our previous efforts are not lost; the *commune vinculum* which connects all the departments of human knowledge, still remains unbroken; the intellect which has been enriched by the elements of science and literature, continues to shed a portion of their lustre over its own particular pursuit, and occasionally to aid, by useful suggestions and partial efforts, those who are travelling upon some other route.

Knowledge is said to be power, it is indeed, power of the most comprehensive and efficient kind, for it depends on no extraneous aid.

Knowledge is nothing but the just and full comprehension of the real nature of things, physical, intellectual, and moral; it is co-extensive with the universe of being, both material and spiritual; it reaches back to the dawn of time, and forward to its consummation; nay, it is coeval with eternity, and is inseparable from the incomprehensible existence of Jehovah. Only one mind therefore, intuitively embraces the whole. Human life is competent to the acquisition of only a very small part of universal knowledge. The greatest and the most enlightened mind, measuring its acquirements by

this standard, will find much cause for humility and none for pride ; but we may look forward to a state of being, where knowledge will be infinitely progressive, and where error is wholly excluded.

It is useful when we are about entering on a professed exhibition of a particular science, and especially of one of so great extent and interest as chemistry, to remember that there are many other interesting and useful branches of knowledge, and that we always assume too much, if we claim all importance and every attraction, for a particular pursuit. The barbarous king of a petty island in the Pacific Ocean, when visited by an American navigator, imagined himself the greatest monarch existing, and enquired what was said of him in other countries. This is necessarily the feeling of every one who insulates himself within his own peculiar dominion ; but he who takes a comprehensive survey of human knowledge, will learn to appreciate justly his own acquisitions, and to concede to others the favor which he would claim for himself.

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